

Water Efficiency Plan

September 2002
Revised January 2003



**National Renewable Energy Laboratory
Golden, CO**

This report prepared for the Sustainable NREL Program by:

Eva Urbatsch
Research Assistant
Washington, DC

Anna Hoenmans
Site Engineer
Golden, Co

Stephanie Tanner
Senior Project Leader
Washington, DC

Contents

Summary Report	6
Background	6
Objective	6
Methodology	6
Summary of BMP Investigation and Implementation Initiatives	7
Table 1: BMP Investigation and Implementation Initiatives	7
Determination and Findings	8
Certification of Final Review and Submission	8
Water Efficiency Plan	9
1.0 Required Background Data	9
1.1 Utility Information	9
Table 2: CMWC Water Rates	10
Meter Size	10
Table 3: Tap Sizes at NREL Buildings	10
Wastewater rates:	10
Table 4: Published Wastewater Rates	11
Bi-Monthly Bill	11
Table 5: NREL's Actual Wastewater Rates	11
1.2 Water Emergency and Drought Contingency Plans	12
1.3 Additional Information	12
Figure 1: Building Water Use at South Table Mountain	13
Figure 2: Map of South Table Mountain Site	14
2.0 Investigating and Categorizing Water Use	15
2.1 Category 1 - Laboratories	15
2.2 Category 2 – Offices	16
2.3 Category 3 – Irrigation Water Use	16
Table 6: Total NREL Irrigation Water Use for FY 2000	17
2.4 Category 4 – Industrial	17
2.5 Category 5 – Leaks, Losses, and Unaccounted for Water	18
Figure 3: Water Survey Results – Water Use Breakdown	19
3.0 Calculating Incremental Costs of Water and Sewage Disposal	20
4.0 Investigation of DOE FEMP BMPs	20
4.1 Analysis of BMP #1 – Public Information and Education Programs	20
4.2 Analysis of BMP #2 – Distribution System Audits, Leak Detection, and Repair	21
4.3 Analysis of BMP #3 – Water Efficient Landscaping	21
4.4 Analysis of BMP #4 – Toilets and Urinals	22
4.5 Analysis of BMP #5 – Faucets and Showerheads	22
4.6 Analysis of BMP #6 – Boiler/Steam Systems	22
4.7 Analysis of BMP #7 – Single-Pass Cooling Systems	23
4.8 Analysis of BMP #8 – Cooling Tower Management	23
4.9 Analysis of BMP #9 – Miscellaneous High Water-Using Processes	24
4.10 Analysis of BMP #10 – Water Reuse and Recycling	24
5.0 Implementation Plan	24
Table 7: Summary of BMP Analysis and Action Items for Implementation	25

5.1	Schedule.....	26
6.0	Program Monitoring.....	26
7.0	Conclusion	27
	Table 8: Annual Water Savings Potential of Selected BMPs	27
	Appendix A: Water and Sewer Bills from FY 00 and FY 01	28
	List of Abbreviations	28
	Water Bills: FY 2000.....	28
	Sewer Bills: FY 2000.....	31
	Water Bills: FY 2001	31
	Sewer Bills: FY 2001.....	34
	Appendix B: Memo from Consolidated Water Mutual	35

Tables

Table 1: BMP Investigation and Implementation Initiatives	7
Table 2: CMWC Water Rates	10
Table 3: Tap Sizes at NREL Buildings	10
Table 4: Published Wastewater Rates	11
Table 5: NREL's Actual Wastewater Rates	11
Table 6: Total NREL Irrigation Water Use for FY 2000	17
Table 7: Summary of BMP Analysis and Action Items for Implementation	25
Table 8: Annual Water Savings Potential of Selected BMPs	27

Figures

Figure 1: Building Water Use at South Table Mountain	13
Figure 2: Map of South Table Mountain Site	14
Figure 3: Water Survey Results – Water Use Breakdown	19

Summary Report

Background

Executive Order 13123, Greening the Government through Efficient Energy Management, and DOE Order 430.2A, Departmental Energy and Utility Management, mandate an aggressive policy for reducing potable water consumption at federal facilities. Implementation guidance from the U.S. Department of Energy (DOE) set a requirement for each Federal agency to “reduce potable water usage by implementing life cycle, cost effective water efficiency programs that include a water management plan, and not less than four Federal Energy Management Program (FEMP) Best Management Practices (BMPs).”

To comply with the Executive Order and implementation guidance, each facility must develop an installation-specific water management plan by 2005. The plans must be incorporated into established operation or facility plans. The following percentages of facilities must implement at least four BMPs by the dates shown.

- 5 percent of Federal facilities by 2002
- 15 percent of Federal facilities by 2004
- 30 percent of Federal facilities by 2006
- 50 percent of Federal facilities by 2008
- 80 percent of Federal facilities by 2010

Objective

The objective of this plan is to achieve full compliance with Executive Order 13123 and DOE Order 430.2A on behalf of **NREL-owned facilities**. To develop the plan NREL staff relied on a process defined in the *Air Force Water Conservation Guidebook*, published by HQ Air Force Civil Engineer Support Agency (HQAFCESA) in May 2002.

Methodology

Using this process, NREL has, as of September 30, 2002:

- Developed water management plan attached to this Summary Report.
- Incorporated this plan as a component of the Sustainable NREL Master Plan.
- Investigated the water saving potential and life-cycle cost effectiveness of the operations and maintenance (O&M) and retrofit/replacement options associated with the ten FEMP BMPs.
- Identified retrofit/replacement options for implementation (based on calculation of the simple payback periods).
- Established a schedule for implementing applicable and cost-effective retrofit/replacement options.

Summary of BMP Investigation and Implementation Initiatives

Table 1 summarizes the BMP implementation initiatives at NREL. Details of the investigative activity are included in Section 4.0 of the Water Management Plan.

In accordance with FEMP guidelines, a BMP can be considered implemented when the “applicable operations and maintenance options have been put into practice, and retrofit/replacement options have been reviewed within the last two years and those appropriate for implementation have been identified; and the cost-effective retrofit/replacement options identified have been implemented.”

Table 1: BMP Investigation and Implementation Initiatives

Best Management Practice	Implemented O&M Options?	Selected for Implementation?	Claim Credit for BMP Implementation?
#1 Public Information and Education Programs	N/A	Recommended for FY 2003	No
#2 Distribution System Audits, Leak Detection, And Repair	Further investigation recommended		No
#3 Water Efficient Landscaping	Yes	Recommended for FY 2003	No
#4 Toilets and Urinals	Yes	Yes	Yes
#5 Faucets and Showerheads	Yes	Yes	Yes
#6 Boiler/Steam Systems	Further investigation recommended		No
#7 Single-Pass Cooling Equipment	Further investigation recommended		No
#8 Cooling Tower Management	Further investigation recommended		No
#9 Misc. High Water-Using Processes	No	No	No
#10 Water Reuse and Recycling	No	No	No

Determination and Findings

NREL is on the path to full compliance, as demonstrated by these investigation and implementation measures. NREL has completed the installation-specific Water Efficiency Plan and implemented the following BMPs for FY 2002:

- BMP #4 Toilets and Urinals
- BMP #5 Faucets and Showerheads

The following BMPs are recommended for implementation for FY 2003:

- BMP #1 Public Information and Education Programs
- BMP #3 Water Efficient Landscaping

To maintain compliance, NREL will re-evaluate the applicability of BMP retrofit/replacement options within the next two years. If the economics of any option improves to the point that it warrants implementation, NREL will amend the water management plan and implement those options.

Certification of Final Review and Submission

The undersigned certifies the attached installation-specific water management plan has been reviewed, and with his signature submits the plan in compliance with Executive Order 13123 and DOE Order 430.2A.

Authorizing Signature (date),

Robert Westby
Lead: Sustainable NREL
National Renewable Energy Laboratory

John Shaffer
Director, Site Operations

Randall McConnell
Director, Environment, Safety and Security

Attachment: (1) NREL Water efficiency plan dated September 30, 2002

Water Efficiency Plan

This plan was developed in compliance with Executive Order 13123 and DOE Order 430.2A according to the process defined in the *Air Force Water Conservation Guidebook*, published by HQ AFCEA in May 2002. The water efficiency plan consists of the following sections:

- Required Background Data
- Investigating and Categorizing Water Use at NREL
- Calculating Incremental Costs of Water and Sewage Disposal
- Implementation Plan
- Program Monitoring

1.0 Required Background Data

To develop this water efficiency plan, NREL collected specific background data related to: (1) utility information; (2) water emergency and drought contingency plans; and (3) additional information requirements. These data components are included in the NREL Water Efficiency Plan.

NREL has two sites in Colorado—the main site at South Table Mountain (STM) in Golden, and the National Wind Technology Center (NWTC) between Golden and Boulder. The NWTC does not have a public water utility connection; water is trucked into the site. This analysis focuses on the STM site, although the recommendations apply to NWTC.

1.1 Utility Information

Point of contact (POC), telephone numbers, and addresses of all public water and wastewater utilities that serve NREL

Water supplied by:
Consolidated Mutual Water Company
12700 W. 27th Avenue
Lakewood, CO 80215
(303) 238-0451

Sewer (wastewater):
Pleasant View Water and Sanitation District
955 Moss Street
Golden, CO 80401
(303) 279-3391

Water rates

The minimum rates and gallonages (Table 2) apply bi-monthly. The previous rates and gallonages are shown in parentheses for convenience in making comparisons. The new rates became effective February 1, 2001. The rates are available at: <http://www.cmwc.net/rates.aspx>

Table 2: CMWC Water Rates

Meter Size	Bi-Monthly Minimum Bill		Bi-Monthly Gallage Allowance	
5/8" Displacement	\$29.80	(\$28.60)	4,000	(4,000)
3/4" Displacement	\$44.80	(\$43.00)	9,000	(9,000)
1" Displacement	\$74.60	(\$71.60)	21,000	(21,000)
1 1/2" Displacement	\$149.20	(\$143.20)	48,000	(47,000)
2" Compound	\$238.70	(\$229.10)	81,000	(79,000)
2" Turbine	\$298.40	(\$286.30)	102,500	(100,500)
3" Compound	\$477.40	(\$458.10)	168,000	(165,000)
3" Turbine	\$671.40	(\$644.30)	238,500	(235,000)
4" Compound	\$746.00	(\$715.90)	266,000	(261,500)
4" Turbine	\$1,865.00	(\$1,789.60)	674,000	(664,500)
6" Compound	\$1,492.00	(\$1,431.70)	538,000	(530,000)

All water used in excess of the minimum allowance is charged at \$2.65/kgal (previous rate was \$2.55/kgal). Unused gallage allowances may not be carried forward. No combination or aggregation of charges for service to a consumer through two or more meters shall be made. Tap sizes at NREL are shown in Table 3.

Table 3: Tap Sizes at NREL Buildings

Building	Tap Size
Alternative Fuels User Facility (AFUF)*	1 1/2"
Biotechnology Research Facility (BTRF)*	1 1/2"
FETA**	1 1/2"
Field Test Laboratory Building (FTLB)	3" Compound
Maintenance Building (MAINT)	1 1/2"
Outdoor Test Facility (OTF)***	1 1/2"
Shipping and Receiving (S/R)	1 1/2"
Site Entrance Building (SEB)	3/4"
Solar Energy Research Facility (SERF)	3" Compound
Thermal Test Facility (TTF)	1 1/2"
Visitors Center (VC)	1 1/2"

- * The AFUF and BTRF share a building.
 ** The OTF obtains its water from this tap.
 *** This tap is not used.

Wastewater rates

Pleasant View Water and Sanitation (PVWS) District charges a flat, bi-monthly rate for sewer services. Its charge structure is illustrated in Table 4.

Table 4: Published Wastewater Rates

Water Meter Size	SFRE *	Bi-Monthly Bill
0.75"	1.9	\$41.80
1"	4.5	\$99.00
1.5"	11.0	\$242.00
2"	20.0	\$440.00
3"	42.0	\$924.00
4"	76.0	\$1672.00

*Single Family Residency Equivalence, the base unit of metering used by PVWS.

NREL is outside PVWS's service area, so it is charged at the rates shown in Table 5. (The normal charge for providing sewer service outside the normal service area is twice the standard rate.) These rates, which are less than twice the standard rates, were negotiated with PVWS when the taps were originally installed.

Table 5: NREL's Actual Wastewater Rates

Building	Bi-Monthly Bill
SERF	\$1056.00
Site	\$528.00
TTF	\$264.00
Total	\$1828.00

Water and sewer bills

The FY 2000 and FY 2001 water and sewer bills are provided in Appendix A.

Information from water and wastewater utilities detailing all financial and technical assistance available for planning and implementing water efficiency programs

No technical or financial assistance is available from Consolidated Mutual Water Company (CMWC) or PVWS. However, Denver Water offers free audits to its customers. Since CMWC is a member of Denver Water's service area, NREL was able to get a free water audit. On August 15, 2002, Jim Reed of Denver Water, accompanied by Anna Hoenmans and Eva Urbatsch, audited the SERF and the FTLB.

POCs, telephone numbers, and addresses for the NREL offices charged with the responsibility to pay water and sewer bills.

Bill Payment:

Finance Office
BLDG 17 - 264
303-275-4500 (phone)
303-275-4520 (fax)

Bill Data Collection:

Site Operations Engineering & Construction
BLDG 27
303-384-7432 (direct)
303-384-7330 (fax)
POC: Anna Hoenman

Production information

This section is not applicable because NREL neither produces potable water, nor treats its own wastewater.

1.2 Water Emergency and Drought Contingency Plans

NREL does not have a Drought Contingency Plan or a Contingency Response Plan at this time. However, as of September 16, 2002, NREL suspended outdoor lawn watering in compliance with a CWMC directive (Appendix B).

1.3 Additional Information

To satisfy the additional information requirements of the Executive Order and the DOE implementation guidance, this water management plan was incorporated into the NREL Energy Management Plan. As such, O&M recommendations from the FEMP BMPs will be incorporated into laboratory policy and procedures. In addition, inclusion of the water management plan in NREL's Energy Management Plan will satisfy comprehensive planning requirements to "inform staff, contractors, and the public of the priority NREL places on water and energy efficiency."

A water use breakdown (Figure 1) was completed. As the SERF and the FTLB represent 85% of NREL's water use, the information collected and recommendations focus mainly on these two buildings. The FTLB also supplies water to the Solar Radiation Research Laboratory, on the Mesa Top. A map of the STM site is included as Figure 2.

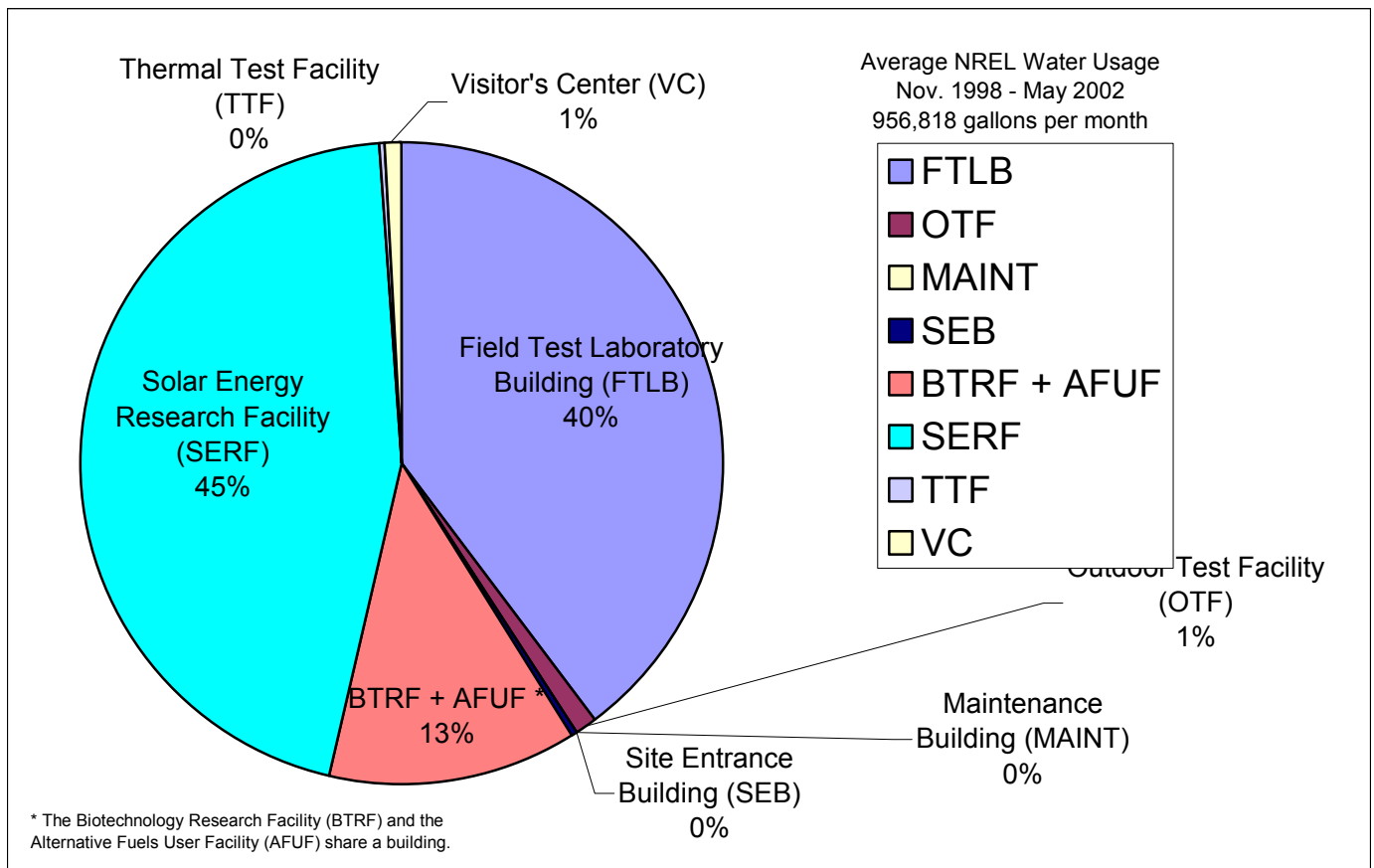


Figure 1: Building Water Use at South Table Mountain

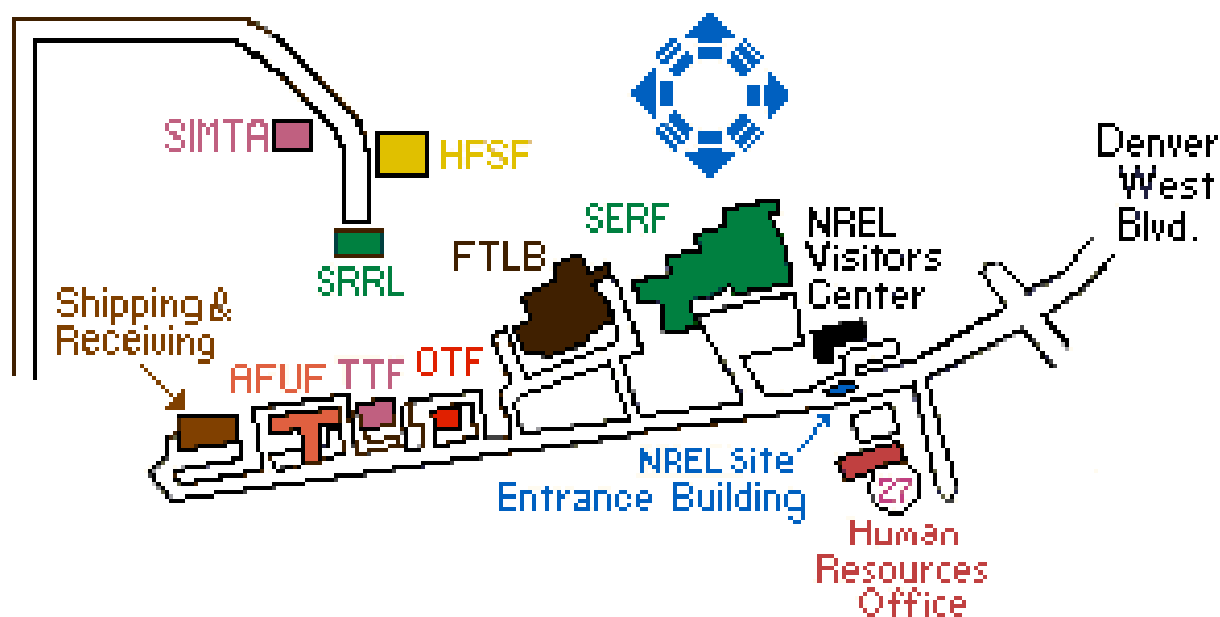


Figure 2: Map of South Table Mountain Site

AFUF	Alternative Fuels User Facility	Researches development of cost-competitive renewable transportation fuels from biomass
FTLB	Field Test Laboratory Building	Researches uses of renewable resources and waste for fuels, electricity and chemicals. Develops new and more efficient industrial processes
HFSF*	High-Flux Solar Furnace	Concentrates sunlight for industrial applications such as materials processing
OTF	Outdoor Test Facility	Provides independent testing of photovoltaic products
SERF	Solar Energy Research Facility	Research facility for developing technologies that convert sunlight into electricity
SIMTA/ SRRL*	Solar Industrial Mesa Top Area/Solar Radiation Research Laboratory	Gathers solar radiation and meteorological data.
TTF	Thermal Test Facility	Develops, tests, and optimized advanced energy-saving technologies to reduce energy use in buildings
VC	Visitors Center	Showcases the benefits of using renewable energy and energy efficiency technologies
NWTC	National Wind Technology Center	Researches, develops, and tests wind turbines (located between Boulder and Golden)

* HFSF, SIMTA, and SRRL – the “Mesa Top” facilities – get their water from the FTLB.

2.0 Investigating and Categorizing Water Use

The FEMP guidance recommends conducting the recommended walk-through audit as a minimum to develop the site water management plan. By contacting the serving water utility (CMWC) NREL was able to obtain a free water audit from Denver Water. It should be noted that the general lack of secondary meters has required NREL to estimate water use in several categories using the process defined in the *Air Force Water Conservation Guidebook* to develop a “credible and defensible estimate for water use by facility category.” The following water use categories were designated for investigation:

- Category 1 – Laboratories
- Category 2 – Offices
- Category 3 – Irrigation Water Use
- Category 4 – Industrial
- Category 5 – Leaks, Losses, and Unaccounted for Water Use

Total water use for the lab during fiscal year 2000 was 12,943,000 gallons.

2.1 Category 1 - Laboratories

Most of the square footage at NREL is devoted to laboratories. This category includes all water used directly in research or to operate equipment used in research. There are many different types of research related, water-using equipment in use at NREL including distillers, autoclaves, and fermenters. Annual water use in the category was determined to be 2 percent of NREL FY 2000 water use. This number reflects only deionized water use, and does not reflect other laboratory use, such as laboratory sinks and cooling processes, for which usage data were not available.

The AFUF has two distillers in the facility that use domestic cold water for experiments. Researchers in the FTLB use steam boilers and fermenters for experiments. The FTLB also has two autoclaves and two dishwashers that use water both for operation and for tempering wastewater. Fermenters in one FTLB laboratory use domestic water for cooling. These machines run as needed. This plan does not intend to interfere with equipment used for scientific ends, but hopes to ensure water is being used efficiently.

The water audit revealed that the one autoclave uses domestic water ineffectively. The water discharge from the autoclaves at the FTLB is tempered by mixing with domestic cold water before it enters the drainage system, which follows plumbing code requirements. The domestic water would run continuously to the drain when the autoclave was not in operation. The water flow was measured at 0.5 gallons per minute (gpm), which translates to 262,800 gallons of water per year (gpy) for this piece of equipment. The autoclave next to this one was under repair, but as it is of a similar design, it probably has a comparable water flow. Several small fermenters at the FTLB also had domestic water running continuously, although no measurement of their flow rate was taken. See BMP #7, Single Pass Cooling Equipment, for further discussion on these issues.

Equipment in the SERF is on the process chilled water loop, which recirculates water used for cooling. There is no process chilled water loop in the FTLB because the chiller is shut down during unoccupied hours and runs off free cooling during unoccupied hours

Deionized (DI) water is used for many experimental processes and procedures. Its use is metered. DI water systems are available at the FTLB, AFUF, SERF, and OTF. Records show that 176,926 gal of DI water were produced at SERF and FTLB during FY 2000, accounting for 1.6 percent of the water used in these buildings for this period.

2.2 Category 2 – Offices

Offices in NREL's permanent buildings are interspersed with laboratories and industrial areas. Water use for this category was estimated based on the number of employees of each gender assigned to each building. The assumptions were made that each male employee used the toilet once a day and the urinal twice a day. The female employees were assumed to use the toilet three times each day. All employees were assumed to wash their hands for 10 seconds after each toilet or urinal use. Annual water use in this category was estimated at 647.2 kgal, which is approximately 5 percent of the 12,943 kgal FY 2000 baseline.

2.3 Category 3 – Irrigation Water Use

Irrigation is available at each facility on the NREL campus with exception of the Maintenance Building and the Mesa Top. The irrigation system at the NREL campus is mostly a drip system. There are few sprinkler heads at the FTLB and SERF.

Irrigation water has not been metered at NREL, but was calculated based on the watering schedule provided by Rich Lozano of Site Operations, who further noted that the sprinklers are usually turned on from April to October and are off from November through March. This pattern accounts for 518.8 kgal per year, or about 4.0 percent of NREL's FY 2000 water use.

Table 6: Total NREL Irrigation Water Use for FY 2000

Month	FY 2000 Water Use (kgal)
January	0
February	0
March	0
April	74.1
May	74.1
June	74.1
July	74.1
August	74.1
September	74.1
October	74.1
November	0
December	0
Total	518.8

2.4 Category 4 – Industrial

This category includes water used in either evaporative coolers or cooling towers. The SERF, FTLB, and AFUF have cooling towers and almost all sites within NREL campus, except the SEB, use evaporative cooling. The AFUF cooling tower is mostly used for laboratory experiments.

Evaporative coolers are run from April to October in the SERF and the FTLB. The coolers run about 10-20 minutes every hour. Their water use was calculated in this manner:

$$\frac{0.004 \text{ lb water}}{\text{lb air}} \times \frac{(\text{volume}^*) \text{ ft}^3}{\text{min}} \times \frac{1 \text{ lb air}}{14 \text{ ft}^3} \times \frac{1 \text{ gal}}{8.34 \text{ lb water}} \times \frac{15 \text{ min}}{\text{h}} \times \frac{24 \text{ h}}{\text{d}} \times \frac{30 \text{ d}}{\text{mo}}$$

* The volume in cubic feet per minute varied among the 11 evaporative coolers.

The SERF also runs its evaporative coolers during the winter for humidity control. The evaporative coolers were assumed to run slightly longer (20 min/h) in winter than in summer. Using these assumptions, evaporative coolers were calculated to account for 19 percent of the water use at the SERF from January 2000 through May 2002. The FTLB does not run its evaporative coolers in the winter, so evaporative cooling accounted for only 8.8 percent of total water use during the same period.

Cooling towers are also major users of water at NREL facilities. The cooling tower at the SERF has been metered since January 2000. Through May 2002, cooling tower use at the SERF accounted for 29.7 percent of water use at that facility. The cooling tower at the FTLB has not historically been metered, but its total water use was calculated by Jim Reed of Denver Water to be:

$$\begin{aligned} \text{Evaporation} &= 400 \text{ tons} * 3,912.48 \text{ gal/ton} = 1,564,992 \text{ gpy} \\ \text{Bleed} &= 1,564,992 \text{ gpy} / 3.14 \text{ cycles of concentration} = 498,405 \text{ gpy} \\ \text{Total} &= 2,063,397 \text{ gpy} \end{aligned}$$

Thus, cooling tower use was estimated to account for 29.8 percent of the water use at the FTLB. The SERF and FTLB cooling towers are run at different cycles of concentration, leading to different levels of water use. Metering the FTLB cooling tower would give a more accurate picture of its water use. See BMP #8, Cooling Tower Management, for further discussion.

The combined industrial (evaporative cooling plus cooling tower) use was 5,197.8 kgal, or 47.8 percent of the water used at the SERF and the FTLB during FY 2000.

2.5 Category 5 – Leaks, Losses, and Unaccounted for Water

This category is the difference between the amount of water NREL is using based on water bills and water use identified through the audit process. During fiscal year 2000, 4454 kgal of 10871 kgal, or 41 percent, of water at the FTLB and SERF was unaccounted for as of this writing. Based on the audit of the facilities the following areas could comprise a significant portion of the unaccounted for water:

- Laboratory sinks
- Small single-pass cooling systems
- Distribution and other system leaks
- Process research operations

Figure 3 represents the activities for which water use could be measured or estimated. A substantial amount of water is unaccounted for in this survey. Finding out what this water is used for should be a priority for further investigation. Recommendations to address this are included under BMP #7, Single Pass Cooling Equipment.

SERF + FTLB Water Use By Category FY 2000

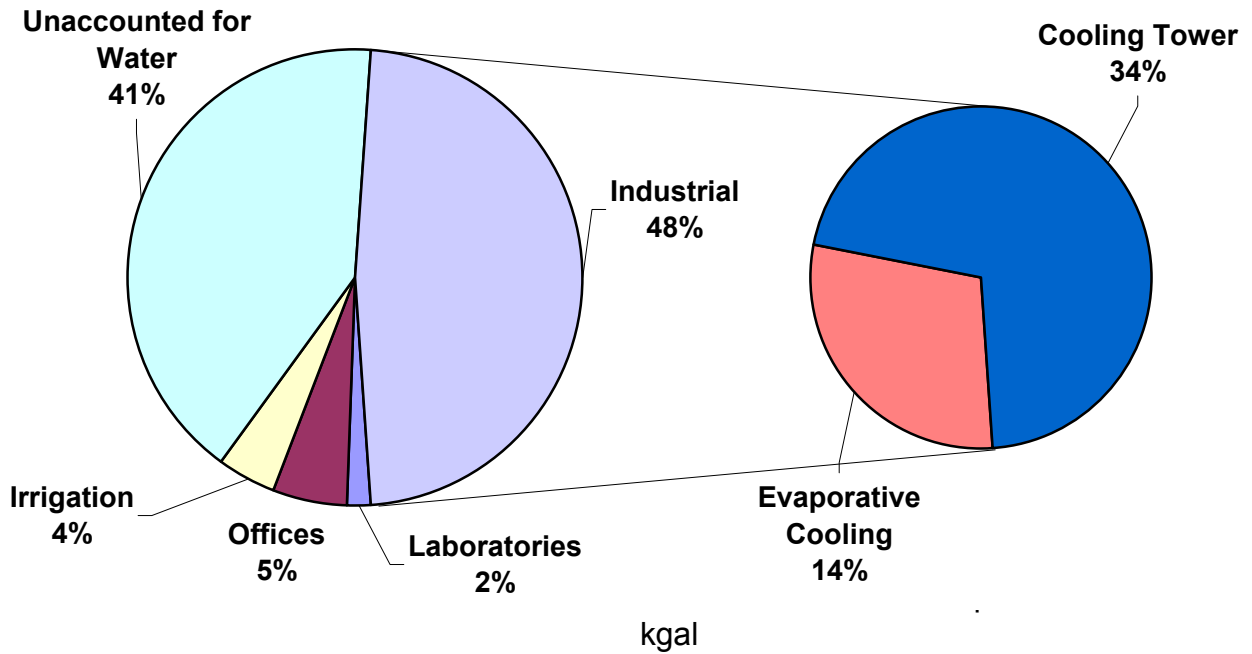


Figure 3: Water Survey Results – Water Use Breakdown

3.0 Calculating Incremental Costs of Water and Sewage Disposal

Incremental water and sewage disposal costs were calculated in accordance with the *Air Force Water Conservation Guidebook*. NREL purchases potable water service from CWMC. Water is charged at a flat rate above a minimum gallonage allowance, or a rate of \$477.40 for 168 kgal for a 3" compound tap. Water use in excess of 168,000 gal is charged at \$2.65/kgal.

The SERF and the FTLB have 3" compound taps. The average water cost since the February 1, 2001 rate change for these two buildings was \$2.694/kgal. As sewer is charged at a flat rate, the incremental cost of sewage is zero. Thus, the incremental cost of using water is just the water rate – \$2.694/kgal.

4.0 Investigation of DOE FEMP BMPs

For this water management plan the investigation of water conservation measures was limited to the ten BMPs that were specially designated by the DOE FEMP:

- BMP #1 - Public Information and Education Programs
- BMP #2 – Distribution System Audits, Leak Detection, and Repair
- BMP #3 – Water Efficient Landscaping
- BMP #4 – Toilets and Urinals
- BMP #5 – Faucets and Showerheads
- BMP #6 – Boiler/Steam Systems
- BMP #7 – Single-Pass Cooling Systems
- BMP #8 – Cooling Tower Management
- BMP #9 – Miscellaneous High Water-Using Processes
- BMP #10 – Water Reuse and Recycling

4.1 Analysis of BMP #1 – Public Information and Education Programs

The benefits and cost effectiveness of this BMP have been demonstrated in common practice. Utility districts implementing public information and education programs report average annual savings of 10–15 percent of total water use.

A public information and education program can support all other water conservation efforts at NREL. Implementation can largely be achieved at little or no cost through currently established public information vehicles, such as *NREL Now* (the weekly online newsletter), the Sustainable NREL Web site, theSOURCE Web site, and *Inside NREL* (the quarterly newsletter). We recommend that this BMP be implemented during FY 2003.

Recommended actions include:

- Placing signs by waterless urinals in the Visitors Center, informing users of the benefits of waterless urinals. (Accomplished as of this writing.)
- Publicizing the Work Control Center number to report leaks or other water waste. This could be tied to the emergency number, with Security notifying the on call maintenance technician about the leaks after normal working hours.
- Working with theSOURCE, *Inside NREL*, Sustainable NREL, and *NREL Now* to publish articles promoting water conservation.

4.2 Analysis of BMP #2 – Distribution System Audits, Leak Detection, and Repair

Since more than 10 percent – 38 percent – of water use at NREL is unaccounted for, more investigation into water use is called for. As NREL buildings are relatively new, leaks are probably not the sources of this missing water. A more thorough water audit might help identify uses of this missing water, but most is probably lost to single-pass cooling equipment (see BMP #7). If, after the audit recommended under BMP #7 is completed, less than 90 percent of NREL's water use is accounted for, a full-scale system audit might be conducted, although no such audit is recommended at this time.

Credit is not claimed for implementation of this BMP.

4.3 Analysis of BMP #3 – Water Efficient Landscaping

As irrigation use was less than 10 percent of total water use, only O&M options were considered for this BMP, although any new facilities being designed should include a water-wise landscape (Xeriscape™) emphasizing native plants and minimal or no turf.

NREL already performs the following O&M actions:

- Verifies annually that irrigation schedule is appropriate for climate, soil conditions, plant materials, grading, and season.
- Waters only in the early mornings to minimize evaporation.
- Places and adjusts sprinkler heads so as to water only the landscape, not the pavement. The one exception to this is the turf area surrounding the FTLB. At the FTLB the sprinkler heads and the sprinkler zoning run parallel to the slope of the turf area, so every sprinkler zone operating would have the water run to the bottom of the slope. This does not water the high turf area effectively, but changing this would require digging up and reseeding the lawn and is not cost effective at this time.
- Monitors irrigation systems for effectiveness.
- Waters plant roots, not trunks or leaves.
- Checks for dirty or broken emitters.
- Ensures that all handheld hoses have shut-off nozzles.
- If turf is lost as a result of the 2002 watering moratorium, will revegetate with native plants.

Publicizing the fact that irrigation system problems should be reported to the Work Control Center by calling x7344 or emailing at wcenter@tcplink.nrel.gov could be incorporated into BMP #1.

Credit is not being claimed for this BMP for FY 2002, although this is recommended for implementation in FY 2003.

4.4 Analysis of BMP #4 – Toilets and Urinals

Replacing the 3.5 gallon per flush (gpf) toilets with 1.6 gpf low-flush toilets and replacing the 1 gpf urinals with waterless urinals should reduce water consumption from these fixtures from 764,250 gpy to 301,600 gpy, a 60.5 percent reduction. This BMP was implemented for FY 2002 at NREL facilities where the replacement was judged to be cost effective, including the NWTC, and credit is being claimed.

4.5 Analysis of BMP #5 – Faucets and Showerheads

Retrofitting the 2.5 gpm faucets with aerators to lower their flow to 1 gpm should reduce water consumed by hand-washing from 168,938 gpy to 67,575 gpy, a 60 percent reduction. This BMP was implemented in FY 2002 at 100 percent of NREL facilities including the NWTC, and credit for this BMP will be claimed.

4.6 Analysis of BMP #6 – Boiler/Steam Systems

All the heating boilers at the SERF and the other FTLB boilers are hot water based, and only discharge water as blowdown. There are several small steam boilers for use at research facilities: the FTLB research autoclave, the FTLB TCUF research boiler, the AFUF York research boiler, and the AFUF research generator.

As the cost of blowdown water is small compared with the costs of heating the water, retrofit and replacement options are not economical and were not considered. The relevant O&M options for this BMP include:

- Maintaining proper water treatment to prevent system corrosion and optimize cycles of concentration.
- Using periodic quality assurance of boiler water treatment.
- Regularly cleaning and inspecting boiler water and fire tubes. Reducing scale buildup will reduce the amount of blowdown necessary as well as improve the energy efficiency of the system.

The only one of these options not currently in place at NREL is regular cleaning and inspection of boiler water and fire tubes, because many of the systems operate year round. Implementing a

regular program of boiler cleanup would allow NREL to claim credit for this BMP and should be considered for future implementation.

4.7 Analysis of BMP #7 – Single-Pass Cooling Systems

Several pieces of process research equipment (such as fermenters and autoclaves at the FTLB) have water running continuously for cooling, even when the equipment is not running. A thorough survey of such equipment should be undertaken to establish which equipment is cooled via single-pass cooling and how much water is lost in this manner. A retrofit option that should be considered would be adding an automatic control to shut off water flow during unoccupied night or weekend hours.

Implementing a process chilled water loop is not recommended, because that would increase the energy cost to run the chillers. Most FTLB laboratories that require process chilled water have purchased their own small chillers. However, one did not purchase such a chiller and uses domestic cold water.

Credit is not claimed for implementation of this BMP, although further investigation is recommended.

4.8 Analysis of BMP #8 – Cooling Tower Management

As cooling towers constitute a primary water use at NREL, they are obvious targets for water conservation efforts. Retrofit/replacement options for this BMP were judged to be cost ineffective based on the high capital cost of replacing a cooling tower, and the inability of water savings to produce a sufficient payback.

Water treatment technologies are available that minimize water use. The AFUF is currently experimenting with a zero discharge system. Because the FTLB cooling tower bleeds at a lower concentration cycle of 3.14 and the SERF cooling tower bleeds at a concentration cycle of 10, the best water saving opportunity is at the FTLB.

O&M options for this BMP could include:

- Metering and recording water use on the FTLB cooling tower.
- Installing conductivity and flow meters on make-up and bleed-off lines.
- Keeping a log of make-up, bleed-off consumption, dissolved solid concentration, evaporation, cooling load, and concentration ratio.
- Selecting a chemical treatment vendor based on “cost to treat 1000 gallons makeup water” and highest “recommended system water cycle of concentration.”

Credit is not being claimed for this BMP, but it is recommended that it be considered for implementation in the future.

4.9 Analysis of BMP #9 – Miscellaneous High Water-Using Processes

Most of the high water-using processes identified in FEMP guidelines, such as laundries, car washes, and fish hatcheries, do not apply to NREL. Laboratory use is currently not monitored; however, it probably uses less water than other use categories. It may be beneficial to concentrate on this BMP in the future, after single-pass cooling use has been addressed and other BMPs have been implemented. Credit is not claimed for this BMP.

4.10 Analysis of BMP #10 – Water Reuse and Recycling

On-site water recycling, i.e., reusing water at the same location for the same purpose, was not applicable at NREL, as NREL does not have any of the water-using processes such as car washes commonly associated with this practice. The idea of using cooling tower blowdown for irrigation was deemed impractical because of the location of irrigated areas relative to cooling towers as well as the presence of water treatment chemicals in the blowdown.

Water reuse was deemed not applicable because NREL does not have water treatment facilities on-site. To use rainwater runoff or gray water, NREL would have to obtain rights to retain this water through the state water district. The request would first be published to provide notice of the application, and downstream individuals could pose objections. NREL's request and any objections would need to be adjudicated in the state water court to seek an apportionment of the available water. Even if NREL obtained such rights, they are not general and would have lower priority than rights obtained earlier by other individuals and entities.

Credit is not claimed for this BMP.

5.0 Implementation Plan

Table 7 summarizes the analysis of all the BMPs, and lists action items for implementation of O&M and/or retrofit and replacement measures.

Table 7: Summary of BMP Analysis and Action Items for Implementation

Best Management Practice	Implemented O&M Options?	Selected for Implementation?	Claim Credit for BMP Implementation?	Action Items Necessary to Claim Credit
#1 Public Information and Education Programs	N/A	Recommended for FY 2003	No	Publicize a number to call to report leaks or other water waste. Work with the Source to publish quarterly articles promoting water conservation.
#2 Distribution System Audits, Leak Detection, And Repair	Further investigation recommended		No	If more than 10% of water usage is unaccounted for after identification of all single-pass cooling systems (See BMP #7), a more thorough leak detection audit is recommended.
#3 Water Efficient Landscaping	Yes	Recommended for FY 2003	No	Publicize a number for reporting irrigation system problems.
#4 Toilets and Urinals	Yes	Yes	Yes	COMPLETED
#5 Faucets and Showerheads	Yes	Yes	Yes	COMPLETED
#6 Boiler/ Steam Systems	Further investigation recommended	Recommended for further investigation	No	Institute a regular schedule of boiler tube cleaning and inspection
#7 Single-Pass Cooling Equipment	Further investigation recommended		No	Inventory laboratory equipment to identify all single-pass cooling systems. Ensure procedures are in place to turn off the water supply when the single-pass cooling equipment is not in operation. Consider putting single-pass equipment on a process loop.
#8 Cooling Tower Management	Further investigation recommended		No	Consider other water treatment methods in order to reduce water usage.
#9 Misc. High Water-Using Processes	No	No	No	
#10 Water Reuse and Recycling	No	No	No	

5.1 Schedule

Two BMPs have been implemented for FY 2002:

- BMP #4 Toilets and Urinals
- BMP #5 Faucets and Showerheads

Two further low-cost BMPs are recommended for implementation in FY 2003:

- BMP #1 Public Information and Education Programs
- BMP #4 Water Efficient Landscaping

Implementation of these BMPs will meet the recommendation to implement at least four of the ten BMPs.

Consistent with NREL's commitment to sustainability, which implies conservation of precious natural resources, NREL wants to implement more than the minimum number of BMPs. The other BMPs that should be considered for implementation if further investigation demonstrates them to be economical include: BMP #7 Single-Pass Cooling Equipment, BMP #6 Boiler/Steam Systems, and BMP #8 Cooling Tower Management. After all such equipment is inventoried and water flow is measured, BMP #2 Distribution System Audits, Leak Detection, And Repair should be evaluated.

6.0 Program Monitoring

To maintain compliance with the Executive Order and DOE FEMP implementation guidance the cost effectiveness of retrofit/replacement options must be re-evaluated within the next two years. The deadline for this re-evaluation is September 30, 2004. At that time the following BMP retrofit/replacement options will be re-evaluated to determine whether economics have become favorable for implementation.

- BMP #2 Distribution System Audits, Leak Detection & Repair
- BMP #6 Boiler and steam systems
- BMP #8 Cooling tower management
- BMP #9 Miscellaneous high water-using processes
- BMP #10 Water reuse and recycling

Site Operations, in collaboration with Sustainable NREL, will undertake responsibility for monitoring results of water conservation BMPs that are implemented. This will be accomplished by measuring water use for the 12-month period following final implementation of cost-effective BMPs, and comparing the new water use to the FY 2000 baseline. Both the number of kgal saved and the cost of water savings will be measured. The results of this monitoring program will be added as an appendix to this water management plan.

7.0 Conclusion

The four BMPs identified for implementation present extremely attractive opportunities for water conservation at NREL. Table 8 reflects the water and dollar savings potential associated with implementation of the six selected BMPs. The aggregate simple payback of the recommended measures is 3.7 years.

Table 8: Annual Water Savings Potential of Selected BMPs

Best Management Practices		Estimated Savings (kgal)	Estimated Dollar Savings	Estimated Implementation	Estimated Cost
#1	Public Information and Education Programs	2444.5	\$6586.29	FY 2003	\$1500-\$1800
#3	Water Efficient Landscaping	2411.3	\$6496.15	FY 2003	
#4	Toilets and Urinals	462.7	\$1246.38	FY 2002	\$52,500 for both BMP #4 and #5
#5	Faucets and Showerheads	101.4	\$273.07	FY 2002	
Total		5419.9	\$14,601.89		\$54,150

Appendix A: Water and Sewer Bills from FY 00 and FY 01

List of Abbreviations

AFUF – Alternative Fuels User Facility
BTRF – Biotechnology Research Facility
FETA – Field Experiment Test Area; the tap where OTF gets its water
FTLB – Field Test Laboratory Building
MAINT – Maintenance Building
OTF – Outdoor Test Facility
S/R – Shipping and Receiving
SEB – Site Entrance Building
SERF – Solar Energy Research Facility
TTF – Thermal Test Facility
VC – Visitors Center

Water Bills: FY 2000

	M# 33553 - AFUF	
	100 gallons	Cost
November	1040	\$ 261.64
January	505	\$ 135.38
March	1325	\$ 343.58
May	1135	\$ 297.03
July	1565	\$ 402.38
September	1100	\$ 288.45
TOTAL	6,670	\$1,728.46

	M# 33550 - BTRF	
	100 gallons	Cost
November	2545	\$ 616.82
January	1045	\$ 262.82
March	820	\$ 219.85
May	880	\$ 234.55
July	1540	\$ 396.25
September	1300	\$ 337.45
TOTAL	8,130	\$2,067.74

	M# 33375 - FETA	
	100 gallons	Cost
November	202	\$ 134.20
January	185	\$ 134.20
March	117	\$ 139.00
May	86	\$ 139.00
July	218	\$ 139.00
September	277	\$ 139.00
TOTAL	1,085	\$ 824.40

	M# 33345 - FTLB	
	100 gallons	Cost
November	7795	\$ 1,850.22
January	5720	\$ 1,360.52
March	5185	\$ 1,291.28
May	8165	\$ 2,021.38
July	12540	\$ 3,093.25
September	10610	\$ 2,620.40
TOTAL	50,015	\$12,237.05

	M# 33563 - MAINT.	
	100 gallons	Cost
November		\$ 134.20
January		\$ 134.20
March		\$ 139.00
May	5	\$ 139.00
July	5	\$ 139.00
September	15	\$ 139.00
TOTAL	25	\$ 824.40

	M# 33385 -OTF	
	100 gallons	Cost
November		\$ 134.25
January		\$ 134.20
March		\$ 139.00
May		\$ 139.00
July		\$ 139.00
September		\$ 139.00
TOTAL		\$ 824.45

	M#33566 - S/R	
	100 gallons	Cost
November	150	\$ 134.20
January	30	\$ 143.20
March	125	\$ 139.00
May	40	\$ 139.00
July	70	\$ 139.00
September	160	\$ 139.00
TOTAL	575	\$ 833.40

	M#33303 - SEB	
	100 gallons	Cost
November	55	\$ 40.30
January	36	\$ 40.30
March	31	\$ 41.70
May	51	\$ 41.70
July	61	\$ 41.70
September	54	\$ 41.70
TOTAL	288	\$247.40

	M# 33365 - SERF	
	100 gallons	Cost
November	7865	\$ 1,866.74
January	8395	\$ 1,991.82
March	9200	\$ 2,274.95
May	10480	\$ 2,588.55
July	12005	\$ 2,962.18
September	10750	\$ 2,654.70
TOTAL	58,695	\$ 14,338.94

	M#33400 - TTF	
	100 gallons	Cost
November	15	\$134.20
January	8	\$134.20
March	9	\$ 139.00
May	13	\$ 139.00
July	33	\$ 139.00
September	46	\$ 139.00
TOTAL	124	\$824.40

	M# 33305 -VC	
	100 gallons	Cost
November	75	\$ 134.20
January	35	\$ 134.20
March	35	\$ 139.00
May	205	\$ 139.00
July	290	\$ 139.00
September	220	\$ 139.00
TOTAL	860	\$824.40

Sewer Bills: FY 2000

	SERF (11234)	Site (11201)	TTF (11240)
November	\$1056	\$528	\$264
January	\$1056	\$528	\$264
March	\$1056	\$528	\$264
May	\$1056	\$528	\$264
July	\$1056	\$528	\$264
September	\$1056	\$528	\$264
TOTAL	\$6,336.00	\$3,168.00	\$1,584.00

Water Bills: FY 2001

	M# 33553 - AFUF	
	100 gallons	Cost
November	830	\$ 222.30
January	745	\$ 201.48
March	1335	\$ 363.78
May	555	\$ 164.88
July	860	\$ 242.65
September	1295	\$ 353.58
TOTAL	5,620	\$ 1,548.67

	M# 33550 - BTRF	
	100 gallons	Cost
November	620	\$ 170.85
January	955	\$ 252.93
March	1450	\$ 393.10
May	670	\$ 194.20
July	1115	\$ 307.68
September	1605	\$ 432.63

TOTAL	6,415	\$ 1,751.39
	M# 33375 - FETA	
	100 gallons	Cost
November	78	\$139.00
January	67	\$139.00
March	96	\$143.20
May	360	\$143.20
July	297	\$143.20
September	76	\$143.20
TOTAL	974	\$850.80

	M# 33345 -FTLB	
	100 gallons	Cost
November	5730	\$ 1,424.80
January	5220	\$ 1,299.85
March	6035	\$ 1,576.28
May	7140	\$ 1,858.05
July	13845	\$ 3,567.83
September	10130	\$ 2,620.50
TOTAL	48,100	\$ 12,347.31

	M# 33563 - MAINT.	
	100 gallons	Cost
November	45	\$ 139.00
January	5	\$ 139.00
March	5	\$ 143.20
May	5	\$ 143.20
July	5	\$ 143.20
September	5	\$ 143.20
TOTAL	70	\$ 850.80

	M# 33385 -OTF	
	100 gallons	Cost
November	0	\$139.00
January	0	\$139.00
March	0	\$143.20
May	0	\$143.20
July	0	\$143.20
September	0	\$143.20
TOTAL		\$850.80

	M#33566 - S/R	
	100 gallons	Cost
November	105	\$139.00
January	35	\$139.00
March	155	\$143.20
May	40	\$143.20
July	130	\$143.20
September	100	\$143.20
TOTAL	565	\$850.80

	M#33303 - SEB	
	100 gallons	Cost
November	36	\$ 41.70
January	27	\$ 41.70
March	29	\$ 43.00
May	32	\$ 43.00
July	57	\$ 43.00
September	58	\$ 43.00
TOTAL	239	\$ 255.40

	M# 33365 - SERF	
	100 gallons	Cost
November	7645	\$ 1,893.98
January	7525	\$ 1,864.58
March	6895	\$ 1,795.58
May	7325	\$ 1,905.22
July	9885	\$ 2,558.02
September	9705	\$ 2,512.12
TOTAL	48,980	\$12,529.50

	M#33400 - TTF	
	100 gallons	Cost
November	24	139.00
January	26	139.00
March	18	\$ 143.20
May	11	\$ 143.20
July	21	\$ 143.20
September	38	\$ 143.20
TOTAL	138	\$ 850.80

	M# 33305 -VC	
	100 gallons	Cost
November	320	\$139.00
January	255	\$139.00
March	30	\$143.20
May	60	\$143.20
July	155	\$143.20
September	265	\$143.20
TOTAL	1,085	\$850.80

Sewer Bills: FY 2001

	SERF (11234)	Site (11201)	TTF (11240)
November	\$1056	\$528	\$264
January	\$1056	\$528	\$264
March	\$1056	\$528	\$264
May	\$1056	\$528	\$264
July	\$1056	\$528	\$264
September	\$1056	\$528	\$264
TOTAL	\$6,336.00	\$3,168.00	\$1,584.00

Appendix B: Memo from Consolidated Water Mutual



IMPORTANT NOTICE

TO: ALL STOCKHOLDERS / USERS
FROM: WALTER S. WELTON, PRESIDENT
DATE: MAY 9, 2002
RE: **MANDATORY WATER RESTRICTIONS FOR ALL CONSOLIDATED USERS**

As you know, due to extremely dry conditions Denver Water and others have implemented voluntary water restrictions aimed at reducing water consumption by 10%. Consolidated needs to reduce use by at least 20%, therefore, upon approval of the Board of Directors of The Consolidated Mutual Water Company and pursuant to Article VII, Section 1.(g) of the Company By-Laws, mandatory outside water use restrictions are being implemented for all Consolidated water users effective **May 22, 2002**. Those restrictions are:

- If the last digit of your address is an **even** number, outside watering is allowed for **two (2) hours** on **Tuesdays** and **Saturdays** only.
- If the last digit of your address is an **odd** number, outside watering is allowed for **two (2) hours** on **Wednesdays** and **Sundays** only.
- Don't waste water and please follow conservation tips.

Violations

- The first violation of these restrictions will result in a written warning.
- The second violation will result in a \$50 fine being added to the water bill.
- The third violation will result in a \$150 fine being added to the water bill.
- The fourth violation will result in a \$300 fine being added to the water bill. Further violations will result in the termination of water service and possible legal action.

Watering with Irrigation Ditch Rights and/or Wells

- If you are using an irrigation ditch or well water, please place a **"Ditch Water"** or **"Well Water"** sign where it is visible from a public street. Please be prepared to validate your ditch right ownership or well location.

The Company, at its sole discretion, may grant exceptions to these restrictions under certain circumstances. The potential for more severe restrictions exists, up to and including in-house use only, to assure that there is an adequate supply of water for the balance of the summer and through next winter. Your cooperation is greatly appreciated and if you have any questions, please call the office at (303) 238-0451.

THE CONSOLIDATED MUTUAL WATER COMPANY
12700 West 27th Avenue • P.O. Box 150068 • Lakewood, Colorado 80215
Telephone (303)238-0451 • Fax (303)237-5560